HEATSINKING OF OPTICAL SUBASSEMBLY AND METHOD OF ASSEMBLING

Background

The present invention relates to an optical subassembly. More particularly, the optical subassembly of the present invention is provided with a heat wick for effectively dispensing heat away from the optical subassembly.

An optical subassembly is typically configured to be received in a transceiver module and is used to transform optical signals coming from optical fibers to an electrical signal, or to transform an electrical signal to an optical signal. A photodiode or similar optical receiver contained by the optical subassembly transforms the optical signal to the electrical signal and then sends the electrical signal to a processing circuit. A laser diode, pin diode or similar optical emitter contained within the optical subassembly transforms the electrical signal coming from the processing circuit to the optical signal.

The process of converting optical signals to electrical signals and electrical signals to optical signals generates significant heat in the optical subassembly. This generated heat can cause damage to the optical subassembly, to the laser diode and to photodiodes contained in the subassembly and problems for the materials holding the various components together. For example, certain epoxies, solder, or other bonding materials can be negatively affected by significant heat generation in the optical subassembly. An improvement in the art is needed.

Summary

The present invention is an optical transceiver. The optical transceiver has a housing, a circuit board, an optical subassembly and a heat wick. The circuit board is configured to be received within the housing. The optical subassembly has a can and a barrel, and the optical subassembly is mechanically

supported on the housing and electrically coupled to the circuit board. The heat wick is thermally coupled between the can of the optical assembly and the housing.

Brief Description of the Drawings

The accompanying drawings are included to provide a further understanding of the present invention and are incorporated in and constitute a part of this specification. The drawings illustrate the embodiments of the present invention and together with the description serve to explain the principles of the invention. Other embodiments of the present invention and many of the intended advantages of the present invention will be readily appreciated as they become better understood by reference to the following detailed description. The elements of the drawings are not necessarily to scale relative to each other. Like reference numerals designate corresponding similar parts.

Figure 1 is a perspective view of a transceiver module including an optical subassembly and heat wick in accordance with the present invention.

Figure 2 illustrates an exploded view of an optical subassembly and heat wick in accordance with the present invention.

Figure 3 illustrates a cross section of an optical subassembly and heat wick in accordance with the present invention.

Figure 4 illustrates an end view of an optical subassembly and heat wick in accordance with the present invention.

Figure 5 illustrates a perspective view of transceiver module with optical subassembly and heat wick in accordance with the present invention.

Figure 6 illustrates a cross section of an optical subassembly and heat wick mounted to a housing in accordance with the present invention.

Figure 7 illustrates a heat wick mounted to a housing in accordance with the present invention.

Figure 8 illustrates a perspective view of an alternative embodiment of a transceiver module with optical subassembly and heat wick in accordance with the present invention.

Detailed Description

In the following Detailed Description, reference is made to the accompanying drawings, which form a part hereof, and in which is shown by way of illustration specific embodiments in which the invention may be practiced. In this regard, directional terminology, such as "top," "bottom," "front," "back," "leading," "trailing," etc., is used with reference to the orientation of the Figure(s) being described. Because components of embodiments of the present invention can be positioned in a number of different orientations, the directional terminology is used for purposes of illustration and is in no way limiting. It is to be understood that other embodiments may be utilized and structural or logical changes may be made without departing from the scope of the present invention. The following detailed description, therefore, is not to be taken in a limiting sense, and the scope of the present invention is defined by the appended claims.

Figure 1 illustrates transceiver module 10 in accordance with the present invention. Transceiver module 10 includes housing 12, printed circuit board 14, first optical subassembly 15, second optical subassembly 16, and heat wick 18. In operation, the various components of transceiver module 10 are assembled and then connected to optical connectors, such a fiber optic cable, on one side and to a host system, such as a router, computer or other electrical device, on another. Transceiver module 10 then transforms electrical signals to optical signals and/or transforms optical signals into electrical signals. Most often, two optical subassemblies 15 and 16 are placed within transceiver module 10, one a transmit subassembly and one a receive subassembly. It is also possible to have a single optical subassembly in accordance with the present invention as well.

Housing 12 includes a nose portion 22 and a frame portion 23. Printed circuit board 14 is mounted to frame portion 23 and optical subassemblies 15 and 16 are mounted between circuit board 14 and nose portion 22. Optical subassemblies 15 and 16 are mounted such that one end of each can be coupled

to the circuit board 14 and another end of each couples into nose portion 22. Optical subassemblies 15 and 16 may be secured by a seat or nest on frame portion 23 such that they are mechanically supported on housing 12.

Circuit board 14 carries various components thereon. Typically, these components include semiconductor chips and related electrical circuitry that facilitate the processing of electrical and optical signal conversion. Optical subassemblies 15 and 16 illustrated in Figure 1 include leads 35 projecting from the subassemblies that are connected directly to circuit board 14. Alternatively, flex leads (not shown in Figure 1) that are made of a conducting material can be used and configured to electrically couple circuit board 14 with optical subassemblies 15 and 16.

One of optical subassemblies 15 and 16 functions as an optical transmitter and the other functions as an optical receiver, and each include subassembly leads 35. Leads 35 are electrically coupled to circuit board 14 when transceiver module 10 is fully assembled. Optical subassemblies 15 and 16 may include a photodiode or similar optical receiver, for transforming optical signals to electrical signals. Optical subassemblies 15 and 16 may also, or alternatively, include a laser, pin diode, or a similar optical emitter for transforming electrical signals to optical signals. In one alternative embodiment, a single optical subassembly is used, the single optical subassembly being a bidirectional optical subassembly. In this case, the components for both transmitting and receiving are contained within the single optical subassembly. Whether an optical subassembly is functioning as an optical transmitter or as an optical receiver, it will contain some sort of optoelectronic device, such as a photodiode or a laser. Consequently, it will generate significant heat during operation.

Heat wick 18 is configured to be assembled to optical subassembly 15 and/or to optical subassembly 16 in accordance with the present invention. When completely assembled, heat wick 18 conductively couples optical assembly 15 and/or 16 with housing 12. Heat wick 18 thereby provides an efficient thermal path from optical assembly 15 and/or 16, which tend to be hot,

to housing 12, which tends to be relatively cooler. Heat wick 18 is configured to be flexible thereby providing variable position control.

Figure 2 illustrates optical subassembly 16 and heat wick 18 in accordance with the present invention. Heat wick 18 is also connectable to optical subassembly 15 in the same way, but for succinctness of description, a single subassembly will be illustrated. Optical subassembly 16 includes subassembly barrel 36 and optical can 38. Optical can 38 includes end surface 42. Barrel collar 40 is configured to be placed over subassembly barrel 36. Optical can 38 is a cylindrical can containing a laser or pin diode used for optical conversion. Typically, there is also a lens over the top of the laser or diode such that optical can 38 forms a thematic enclosure.

Optical subassembly 16 is assembled by coupling optical can 38 to subassembly barrel 36. Subassembly barrel 36 is typically plastic or stainless steel. Subassembly barrel 36 must be optically aligned with optical can 38. Consequently, the final alignment dimensions of optical subassembly 16 will not be determined until optical can 38 and subassembly barrel 36 have been optically aligned, typically using a laser-welding process. Subassembly leads 35 extend from the end surface 42 of optical can 38. Optical can 38 may be, for example, a TO-can.

With the present invention, heat wick 18 is then assembled over optical assembly 16. In one embodiment, heat wick 18 includes sleeve 44 and flange 46. Sleeve 44 is configured to compliment the external shape of optical can 38 such that heat wick 18, and specifically sleeve 44, may be readily mounted on optical can 38. In addition, flange 46 is configured to be a flexible material such that it may be bent or twisted in order to be installed in multiple configurations of transceiver module 10 in accordance with the present invention. This flexibility can be useful when the final alignment dimensions of optical subassembly 16 vary slightly based on the final optical alignment of optical can 38 and subassembly barrel 36. In this way, slight variations in the final alignment dimensions of optical subassembly 16 can be compensated for in the flexibility of heat wick 18 during its installation.

Figures 3 and 4 illustrate heat wick 18 mounted on optical subassembly 16 in cross-sectional and end views, respectively. Optical subassembly 16 includes subassembly barrel 36 coupled to optical can 38. Heat wick 18 is mounted to optical can 38. When heat wick 18 is so mounted, there is contact between back surface 42 and a portion of heat wick 18. In addition, there is thermal contact between sleeve 44 and optical can 38. In one embodiment, heat wick 18 is fixed to back surface 42 of optical can 38 using conductive epoxy or silver-filled conductive epoxy. In other embodiments, heat wick 18 may be fixed using any of a variety of bonding materials, including solder or other forms of epoxy. It could also be coupled with a mechanical connection between back surface 42 and heat wick 18. For example, sleeve 44 could be configured as a spring clip such that it clips over optical can 38.

In one embodiment of the invention, heat wick 18 is formed of a thin copper strip. Consequently, heat wick 18 provides a very efficient thermal path away from optical subassembly 16. It is also quite flexible for attachment to housing 12. In this way, once optical subassembly 16 is mounted in housing 12 of transceiver module 10, heat wick 18 can then be installed and bent into place.

Figure 5 illustrates transceiver module 10 as view from the opposite side illustrated in Figure 1. Transceiver module 10 is illustrated with circuit board 14, optical subassemblies 15 and 16 (subassembly 16 not readily visible in Figure 5), and heat wick 18 assembled with housing 12. Optical subassemblies 15 and 16 are typically fixed to circuit board 14 and the combined assembly is mounted onto frame portion housing 12. Once optical subassembly 16 is installed in housing 12, heat wick 18, which has been fixed to end surface 42, can be thermally coupled to housing 12 in a variety of ways. For example, flange 46 of heat wick 18 may project through a slot 52 provided in housing surface 26. Furthermore, housing surface 26 may also have a recess 25 into which flange 46 may be received when it is bent over housing 12. Flange 46 may then be fixed to recess 25 in a variety of ways. For example, a piece of material may be stamped over flange 46 onto housing 12 to hold flange 46 into

recess 25. Similarly, various epoxies and/or solders could be used to fix flange 46 to housing 12.

Optical subassembly 16 and circuit board 14 are assembled within transceiver module 10 such that they are mechanically secured within transceiver module 10 independently of heat wick 18. In this way, heat wick 18 is not relied upon to provide mechanical stability or support for optical subassembly 16 or circuit board 14 within transceiver module 10, but rather, only to thermally couple optical subassembly 16 to housing 12. This provides added flexibility in the assembly process in that there are no mechanical restrictions in thermally coupling optical subassembly 16 to housing 12 with heat wick 18. Since heat wick 18 is not relied upon for mechanical stability, it can be thermally coupled between optical subassembly 16 to housing 12 in a variety of ways consistent with the present invention.

Figures 6 and 7 illustrate optical subassembly 16 being thermally coupled to housing 12 via heat wick 18. In one embodiment, slot 52 may be provided in housing 12 immediately adjacent the location where heat wick 18 is mounted to optical subassembly 16. Upon installation, heat wick 18 is directed through slot 52. Once flange 46 of heat wick 18 is extended through slot 52, it may be bent over onto the surface 26 of housing 12. A recess 25 may be provided on the surface 26 of housing 12 configured to receive flange 46 of heat wick 18. Further, a cover 50 may be provided and configured to also be received in recess 25 to secure flange 46 against housing 12.

In one embodiment, heat wick 18 has sleeve 44 and flange 46, where flange portion 46 originally extends straight up from sleeve 44 when heat wick 18 is added to optical subassembly 16. Flange 46 may be bendable so that once optical subassembly 16 is assembled on housing 12 and heat wick 18 is then added to optical subassembly 16, flange 46 may be bent over against housing 12 to make a good thermal connection. Configuring flange 46 to be flexible or bendable allows flexibility on the assembly of transceiver 10. Various configurations and combinations of housings 12, circuit boards 14, and optical subassembly 16 may be accommodated in accordance with the present invention.

For example, optically aligning can 38 and optical barrel 36 can cause variation in the physical distance that can 38 is from housing 12, as can slight design changes that exist from transceiver to transceiver. Using heat wick 18, with flexible flange 46, allows differing sizes and dimensions for housings 12, circuit boards 14, and optical subassemblies 15 and 16 to be accommodated and for flange 46 to be bent over onto housing 12 to form an effective thermal path from optical subassemblies 15 and 16 to housing 12.

Thermally coupling optical subassemblies 15 and 16 to housing 12 allows an efficient thermal path from hot optical devices to a relatively cool transceiver package. Typically, can 38, and specifically, end surface 42 of optical can 38 is the hottest portion of optical subassembly 15 and 16. Optical can 38, such as a TO-can, is typically metallic and is the focal point for heat generated in optical subassembly 15 and 16, since it contains the laser or pin diode. Fixing heat wick 18 directly to this end surface 42 wicks heat away at the highest source of heat. Housing 12 is typically a zinc die cast or similar material, which provides a good source for dissipating heat. Typically, housing 12 is the largest heat conducting element in a transceiver further adding to its good heat-dissipating characteristics. Wicking the heat away from optical subassembly 15 and 16 will improve the overall performance of transceiver 10 by keeping the laser or pin diode cooler than it would be in the absence of heat wick 18.

Although optical barrel 36 can be made of stainless steel, often it may be made of plastic or similar relatively poor conducting materials. Even where optical barrel 36 is made of stainless steel, it will not dissipate heat as well as a direct connection of heat wick 18 from end surface 42 of optical subassembly 16 to housing 12. Typically, stainless steel would have a thermal conductivity of approximately 18 watts per meter Kelvin. On the other hand, housing 12 made of zinc die cast material typically has high thermal conductivity of about 100 watts per meter Kelvin. Housing 12 is also typically a much larger size relative to optical barrel 36 thereby making a good heat sink for the heat generated

within optical can 38. Heat wick 18 is typically made of copper having a conductivity of approximately 300 watts per meter Kelvin.

Figure 8 illustrates and alternative embodiment of transceiver module 60 with circuit board 64, optical subassembly 66, and heat wick 68 assembled with housing 62. In this embodiment, only a single optical subassembly 66 is used to receive or to transmit. As one skilled in the art will recognize, the present invention is not restricted to a particular number of optical assemblies used in the particular transceiver, or even the number of optical assemblies that are coupled to the housing with a heat wick.

During assembly of optical subassembly 66 into a device such as transceiver module 60, optical subassembly 66 is typically fixed to circuit board 64 and the combined assembly is mounted onto frame portion 73 of housing 62. Optical subassembly 66 is configured to rest in seat 70 and to extend into nose 72 such that a fiber cable connector can interface therewith. After optical subassembly 66 is installed in housing 62, heat wick 68, which has been fixed to an end surface of optical subassembly 66, can be thermally coupled to housing 62 in a variety of ways. For example, a top portion of heat wick 68 may be bent over nose 72 once optical subassembly 66 is fixed in seat 70. Recess 75 may be provided into which the top portion of heat wick 68 may be received when it is bent over nose 72. The top portion of heat wick 68 may then be fixed to recess 75 in a variety of ways. For example, a piece of material may be stamped over heat wick 68 onto nose surface 74 to hold heat wick 68 onto nose 72. Similarly, various epoxies and/or solders could be used to fix heat wick 68 to nose 72.

Optical subassembly 66 and circuit board 64 are assembled within transceiver module 60 such that they are mechanically secured within transceiver module 60 independently of heat wick 68. In transceiver 60 illustrated in Figure 8, optical subassembly 66 is mechanically secured to transceiver module 60 via nest 70. In this way, heat wick 68 is not relied upon to provide mechanical stability or support for optical subassembly 66 or circuit board 64 within transceiver module 60, but rather, only to thermally couple optical subassembly 66 to housing 62. This provides added flexibility in the assembly process in that

there are no mechanical restrictions in thermally coupling optical subassembly 66 to housing 62 with heat wick 68. Since heat wick 68 is not relied upon for mechanical stability, it can be thermally coupled between optical subassembly 66 to housing 62 in a variety of ways consistent with the present invention.

Although specific embodiments have been illustrated and described herein, it will be appreciated by those of ordinary skill in the art that a variety of alternate and/or equivalent implementations may be substituted for the specific embodiments shown and described without departing from the scope of the present invention. This application is intended to cover any adaptations or variations of the specific embodiments discussed herein. Therefore, it is intended that this invention be limited only by the claims and the equivalents thereof.